March 1998 Highlights of the Pulsed Power Inertial Confinement Fusion Program

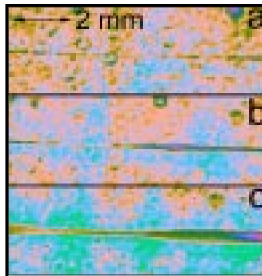


Fig. 1. Laser shadowgraphs at NRL of 10-µm-dia. tungsten wire that is a) unheated, b) pre-heated to 1700 K, or c) to 2300 K.

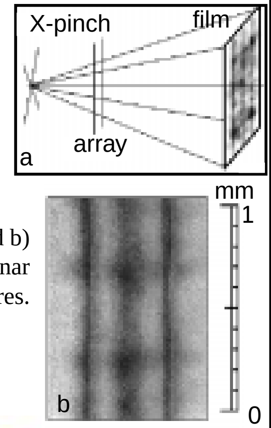
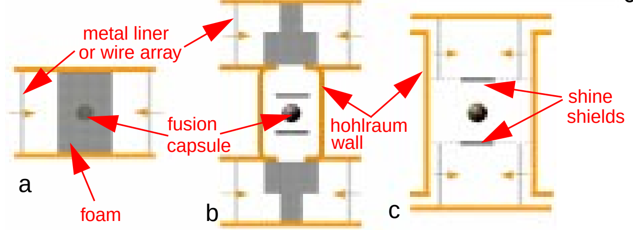


Fig. 2. a) X-pinch imaging scheme and b) backlit image of early dynamics of planar array of exploding W wires.

Fig. 3. a) Internal dynamic hohlraum, b) static-walled hohlraum, c) vacuum hohlraum driven by split wire arrays.



We completed preparation of the Z-pinch Science and Technology Research and Development Plan and defined our milestones through FY2000. Our fourth major milestone on Z, a dynamic-hohlraum radiation temperature of 150 eV, was exceeded in mid March on Shot 214, a double nested wire array shot. Shot 214, with a hohlraum temperature of 155 eV, had an open can with nine azimuthal viewing slots and an annular plastic target. We have formally requested DOE to begin the CD1 approval process (start of conceptual design) for X-1.

We had 19 Z shots this month: one to measure x-rays as an array strikes a central Cu sleeve and stagnates on axis, three to characterize the x-ray environment in an on-axis secondary hohlraum at the end of an on-axis primary, seven to optimize radiation temperature in a dynamic hohlraum driven by nested arrays, one to compare the foam temperature in a dynamic hohlraum with LANL computer models, two to optimize small-diameter nested arrays, four to determine the effect of tamping layers on diagnostic hole closure in a vacuum hohlraum, and one to maximize the temperature in a vacuum hohlraum.

Evaporatively coating the wire arrays to obtain a specific profile of the axial mass density has been proposed as a method to produce axial convergence in z pinches, i.e., a quasi-spherical implosion. This could increase the specific energy density and thus the radiation temperature in a dynamic hohlraum by as much as 30%. The published literature on magnetic Rayleigh-Taylor suggests that the resulting magnetic field curvature could also reduce the instability growth in the pinch. Furthermore, axial convergence reduces dL/dt and hence the voltage across the pinch. Thus, generation of high-energy electrons, which create bremsstrahlung in the vicinity of the pinch, could be reduced. The axial convergence concept will be tested on a future experimental series.

A model has been developed to explain the relation between the full width at half maximum (FWHM) of the radiation pulse and the wire array radius and interwire gap in an array. It is assumed that the wires maintain a distinct wire character throughout most of the implosion, rather than merging early in time. The model accurately predicts the experimental FWHMs for a wide range of Z and Saturn experimental conditions. Optical and x-ray characterization of tungsten wires at early time is being obtained by Troitsk, Cornell, NRL, and Imperial College. Figure 1 suggests that heat preconditioning may have a profound effect on wire dynamics during the Z prepulse. Figure 2, from Cornell experiments with adjacent wires, indicates that a low-current prepulse through the wires produces a high-density, cold core surrounded by a low-density, hot corona. Evidence of a persistent, distinct wire character supports the model assumptions.

The long-term mission of the national ICF program is to produce fusion yields of 200 to 1000 MJ from a capsule. Achieving >200 MJ from a 16-MJ, petawatt x-ray source depends on the hohlraum and capsule design. Three target concepts for X-1 are sketched in Fig. 3: an imploding liner (or dynamic) hohlraum, driven by a single or nested array of wires, with the capsule embedded in foam; a central, static-walled hohlraum with z-pinch x-ray sources at either end; and a central, vacuum secondary with imploding arrays at each end that are isolated from the capsule by burn-through barriers and shine shields. Separating the source from the capsule in the second and third designs minimizes capsule preheat at the cost of x-ray drive efficiency. SNL, LLNL, and LANL are estimating the pulse shaping, symmetry, and energy requirements of a capsule for the three hohlraums using 1D and 2D radiation hydrodynamics codes. General Atomics is assessing the requirements to supply cryogenic DT for the three designs.

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